

**COMPARISON OF REFRACTIVE OUTCOME BETWEEN BIOMETRY  
WITH APPLANATION ULTRASOUND AND PARTIAL COHERENCE  
INTERFEROMETRY ( IOL MASTER ) IN EYES UNDERGOING  
PHACOEMULSIFICATION**

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# *Introduction*

# INTRODUCTION

In modern day ophthalmic practice everybody wants precision. Achieving perfection is one of the greatest challenges and this quest for perfection is the restoration of normal or near normal vision after cataract surgery which is possible with accurate intraocular lens (IOL) power calculation.

Harold Ridley was the first to successfully implant an intraocular lens on November 29, 1949, at St. Thomas Hospital at London <sup>1</sup>. That first intraocular lens was manufactured by the Rayner company of Brighton, East Sussex, England from Perspex CQ polymethylmethacrylate (PMMA) made by ICI (Imperial Chemical Industries). It is said the idea of implanting an intraocular lens came to him after an intern asked him why he was not replacing the lens he had removed during cataract surgery with a new one <sup>2</sup>. As an Air Force Ophthalmologist he observed that retained foreign bodies of aeroplane canopies made of polymethyl methacrylate (PMMA) were tolerated well by the eyes of the pilots of World War II.

The intraocular lens did not find widespread acceptance in cataract surgery until the 1970s, when further developments in lens design and surgical techniques had come about. From Ridley's first lens implantation to the present day, the evolution of IOLs are divided into five generations.

Advances in technology have brought about the use of silicone and acrylic, both of which are soft foldable inert materials. This allows the lens to be folded and inserted into the eye through a smaller incision. PMMA and acrylic lenses can also be used with small incisions.

With further advances the following designs have come up.

- Bifocal or multifocal lens.
- Foldable lens which may be implanted through a 3 mm incision after
- Phacoemulsification. Foldable IOLs are made of silicones, acrylics and hydrogels.
- Injectable lens by introducing a liquid biomaterial into the intact lens capsule. this lens have accommodative capability.

In the past (before the 1980s), IOL power calculations were based primarily on the patient's previous refractive status before cataractous changes occurred. If the patient was an emmetrope, he received an ideal emmetropic lens (IDEM) with IOL power restored to emmetropic status after cataract surgery. The power of the lens was mathematically deduced to be +17.0 D for an AC lens, +19.0 D for an iris fixated lens and +21.0 D for a posterior chamber lens.<sup>3</sup>

The "standard lens", was implanted in the past by making the patient myopic of -1.0 D in order to strike a balance between distance & near vision. This lens had +1.25D sph added to IDEM lens power for adjusting 1.0 D of myopia from the spectacle to the IOL plane.

The IOL power prediction formulae; to achieve greater levels of accuracy in predicting the IOL power that resulted in desired post operative spherical outcomes. 4 generations of IOL formulae were enumerated<sup>4</sup>

Broadly speaking, these formulae could either be Theoretical formulae, which are based on mathematical principles revolving around the schematic eye, or they could be regression formulae, which were derived from post operative outcomes & working backwards (regression analysis) in order to arrive at the IOL power<sup>5</sup> These include Fyodorov, Colenbrander and Binkhorst formulae<sup>6,7</sup>

The second generation regression derived lens power formula, like the SRK II formula<sup>8</sup> have been developed, providing higher accuracy for IOL power determination. The SRK II formula<sup>9</sup> became universal because it is simpler to derive and manipulate than are theoretical formulae. In the past several years, a total of 71% of cataract surgeons exclusively used SRK or SRK II formulas.<sup>10</sup> In addition to the validity of IOL power calculation formulae and the precision of IOL manufacturing, preoperative biometry is a major factor in a favourable post operative refraction. The most important step for an accurate calculation of the IOL power is the preoperative measurement of the ocular axial length (AL).

Optical biometry based on coherence interferometry was developed in the 1990s and is a non-contact method ; an alternative to ultrasound applanation, optical biometry has been proved to be superior in terms of precision, resolution and accuracy of axial length measurements<sup>11</sup>

The IOLMaster (Carl Zeiss, Germany), which is based on the principle of dual beam partial coherence interferometry PCI was produced recently. It uses infrared light ( $\lambda = 780 \text{ nm}$ ) of short coherence for the measurement of the optical AL, which is converted to geometric AL by using a group refractive index. Furthermore, it measures the corneal curvature, the anterior chamber depth, and the corneal diameter and it calculates the optimum IOL power by the acquired biometry data, employing several IOL power calculation formulae built into its computer software. The high precision, resolution, accuracy, and reproducibility of the AL measurements of the IOLMaster have been demonstrated <sup>12-15</sup>. It is a non-contact technique, which does not require use of topical anesthesia, thus providing comfort to the patient and preventing corneal abrasions and the transmission of infections.

A-scan ultrasonography, with a reported longitudinal resolution of approximately  $200 \text{ }\mu\text{m}$  and an accuracy of approximately  $100\text{--}150 \text{ }\mu\text{m}$ , is routinely employed in the measurement of the ocular AL. <sup>16,17</sup> Ultrasound biometry however requires physical contact of a transducer with the eye either directly (contact or applanation) or through an immersion bath of normal saline (immersion).

Optical biometry based on coherence interferometry is a non-contact method. An alternative to ultrasound applanation, it has been proved to be superior in terms of precision, resolution and accuracy of axial length measurements <sup>18</sup>.

In this study the post operative refractive outcome obtained by the IOLMaster was compared with that of applanation ultrasonography.



*Aim*

## **AIM**

To compare the Post-operative refractive outcome employing IOL Master biometry and Applanation ultrasonography in eyes undergoing Phacoemulsification with intraocular lens implantation.

# *Review of Literature*

## REVIEW OF LITERATURE

The refractive power of the human eye depends on the power of the cornea and the lens, the position of the lens, and the length of the eye. Accurate assessment of these variables is essential in achieving optimal postoperative refractive results. For patients who desire optimal refractive outcomes after cataract surgery, proper pre calculation of IOL power is essential.

Accurate biometry is crucial in decreasing errors in IOL power calculation. Other than using accurate formulas, the most critical step in accurate IOL power calculation is axial length measurement <sup>19</sup>. An error in axial length measurement of 100um can result in a postoperative refractive error of 0.28D.<sup>20</sup>

Studies conducted by Olsen showed that imprecision in measurements of anterior chamber depth, axial length and corneal power contribute to 42%, 36% and 22%, respectively of the error in predicted refraction after implantation of IOL <sup>21</sup>

### **Axial length measurement.**

Currently the axial length can be obtained by using either the A-scan ultrasound biometry, or the partial coherence laser interferometer IOLMaster.

An error of 1mm affects the postoperative refraction by 2.5D approximately.

In Ascan ultrasound biometry, a crystal oscillates to generate a high-frequency sound wave that penetrates into the eye. When the sound encounters a media interface,

part of the sound wave is reflected at the internal limiting membrane back toward the probe. These echoes allow us to calculate the distance between the probe and the various structures in the eye.

An alternative technique to measure the axial length is by the non contact laser interferometer(IOL Master; Carl Zeiss Meditec,Jena Germany) it measures the delay and the intensity of infrared light reflected back from media interfaces in order to determine the distance from the cornea to the retinal pigment epithelium.

### **Ultrasound biometry.**

Two types of A-scan ultrasound biometry are currently in use. In applanation biometry an ultrasound probe is placed on the central cornea, and errors in measurement result from probe indenting the cornea and shallowing the anterior chamber. The IOL power calculations using these measurements will lead to an overestimation of the IOL power.

In immersion A-scan biometry a saline filled scleral shell is placed between the probe and the eye and it doesn't exert pressure on the cornea and compression of the anterior chamber is avoided.

In general, immersion biometry has been shown to be more accurate than contact applanation biometry in several studies <sup>22-25</sup>.Hitzenberger et al found that axial lengths measured by optical biometry were 0.18 mm longer than those measured by the

immersion technique and 0.47mm longer than those measured by the applanation technique.<sup>26-27</sup>

## **IOL DEVELOPMENT**

After Harold Ridley inserted the first posterior chamber IOL in 1949, there has been evolution of several generations of IOLs.

### **FIRST GENERATION IOLs**

The first generation lenses experimented by Ridley in 1948 were posterior chamber IOLs.<sup>28-29</sup> The drawbacks of severe postoperative reactions, high incidence of dislocation, glaucoma and iris atrophy led to abandonment of these lenses.

### **SECOND GENERATION (ANTERIOR CHAMBER LENSES)**

These lenses were anterior chamber angle fixated lenses. The two major complications were; corneal decompensation and glaucoma. In most of the cases the lens had to be removed.

### **THIRD GENERATION IOLs (IRIS SUPPORTED, IRIS CLIP LENSES)**

Binkhorst in 1957 developed iris clip lenses which were clipped to the iris with two anterior loops and two posterior loops extending behind the iris through the pupil. Disadvantages were pupillary block glaucoma and iris atrophy. The lens was far in front of the nodal point of the eye.<sup>30-34</sup>

## **FOURTH GENERATION IOLs**

Choyce's anterior chamber one piece lens emerged in 1956. These lenses were easy to insert and had stable fixation. There were as many as nine modifications of this lens<sup>35</sup>

## **FIFTH GENERATION IOLs**

Fifth Generation IOLs are posterior chamber lenses initially modified by removing the posterior two loops of Binkhorst's four loop iris clip lens. Subsequently posterior chamber IOLs for placement in the capsular bag have been designed<sup>36-37</sup>

### **Advantages are;**

- The lens lies close to the nodal point of the eye thereby reducing image magnification and aniseikonia.
- Glare is eliminated because the lens is covered by the iris.
- Pupil mobility is good.
- Fundus view is good.
- There is no damage to the corneal endothelium, trabecular meshwork or iris erosion and chances of late dislocation are nil.

### **Types of IOLs**

Basically there are 2 types;

Three piece lens- optic and haptic made of different or same material.

One piece lens –optic and haptic made of the same material.

## **IOL POWER CALCULATION**

Two methods may be used to calculate the power of the IOL to be implanted in a particular eye;

1. Empirical,
2. Theoretical

Empirical Formula or regression formulae are derived from empirical data and based on retrospective analysis of postoperative refraction after IOL implantation. The results of a large number of IOL implantations are plotted with respect to the corneal power, axial length of the eye, and emmetropic IOL power. In the early days of IOL implant surgery a standard lens of plus 19.0 D was used in all cases. Calculation of IOL Power by Biometry; three basic parameters are necessary to calculate the power by using various formulae;

Anterior chamber depth (by A- scan ultrasonography).

Axial length of the eye (by A-scan ultrasonography).

Keratometry reading in terms of dioptric power of the eye or in terms of radius of curvature with keratometer. The values of the above parameters are inserted to the computer which is programmed in most of the A-scan machines for calculating power by using different formulae.

### **Theoretical formulae**

These formulae are based on an optical model of the eye. An optical model is solved to determine the IOL power needed to focus light from a distant object onto the



retina. In the different formulae, different assumptions are made about the refractive index of the cornea, the distance of the cornea to the IOL, the distance of the cornea to the IOL, the distance of the IOL to the retina as well as other factors. These are called theoretical because they are based on a theoretical optical model of the eye<sup>10</sup>. All the theoretical formulae can be algebraically transformed into the following;

$$P=[N/(L-C)]-[N K/ (N-K C)]$$

Where

P=Dioptric power of the lens for emmetropia

N=Aqueous and vitreous refractive index

L=Axial length (mm)

C=Estimated postoperative anterior chamber depth (mm)

K=Corneal curvature (D)

Fyodorov, Colenbrander and Binkhorst are the theoretical formulae and the most popular one is the Binkhorst formula.

Holladay Formulae; it is said to be a second generation of theoretical formulae. The number of parameters include retinal thickness factor, anterior chamber diameter from angle to angle, surgeon factor, refractive index of cornea and aqueous, and many more.

It is considered as the most accurate formula for power calculation<sup>38</sup>. The formula is easy to optimize and works well across a wide range of axial lengths.

### **The modern formulas**

These include formulas of Holladay I and II, Hoffer Q, SRK/T formula Haigis d- formula and Lin's formula.

#### **Sanders- Retzlaff- Kraff (SRK) Formula**

The most popular regression formula is the SRK formula which was developed by Sanders, Retzlaff and Kraff in 1980. This is given by;

$$P=A-2.5L-0.9K$$

Where,

P=Implant power to produce emmetropia,

L=Axial length (mm),

K=Average keratometer reading, and

A=Specific constant for each lens type and manufacture.

The SRK formula calculates the IOL power by linearly regressing the results of previous implants and it will overestimate the power of low powered lenses and underestimate the power of high powered lenses compared to theoretical calculation.

SRK II Formula; In this formula, the A constant is adjusted to different axial length ranges. It is given by;  $P=A1-0.9K-2.5L$

A1=new constant

A1=A+3 if, axial length L < 20 mm

$A1 = A + 2$  if, L is 20 to 21 mm

$A1 = A + 1$  if, L is 21 to 22 mm

$A1 = A$  if, L is 22 to 24.5 mm

$A1 = A - 0.5$  if, L > 24.5

### **Factors affecting accuracy of IOL power calculation**

Many factors can affect the accuracy of the power of the IOL calculated.

#### **Keratometry**

Keratometers only measure the radius of curvature of the anterior surface. This measurement must be converted to an estimate of the refracting power of the cornea in diopters using a fictitious refractive index. The variability can alter calculated corneal dioptric power by 0.7 D. A 0.25D error in Keratometry corresponds to about 0.25D error in postoperative refraction.

#### **Axial length measurement**

Indentation of the cornea by the Ascan instrument tip can alter the axial length affecting the accuracy of the IOL power and lower the axial length reading. A 0.1 mm error in axial length measurement results in about 0.25 error in postoperative refraction.

#### **Axial length correction factor**

The distance from the vitreoretinal interface to the photoreceptor layer has been estimated to be 0.15 to 0.5mm. This distance can affect the accuracy of the IOL power calculated.

### **Site of loop implantation**

Positioning the posterior chamber IOLs in the capsular bag places the implant further back in the eye and decreases the effective power of the lens. There is usually a 0.5 to 1.5 D loss of effectivity by placing the implant in the capsular bag as opposed to the ciliary sulcus. A high power lens should therefore be used when the implant is placed in the capsular bag.

### **A-Constant error**

A-Constant error in SRK formula may also be a source of error in IOL power calculation.

A-Constant represent averages of A-Constants for a particular design of IOL determined by a group of surgeons which are dependent on the surgical technique adopted by those particular surgeons. These values may not be accurate for another surgeon using the same IOL design.

### **Orientation of planoconvex implants**

Flipping of the implant with the plano surface of the lenses forward decreases the effective power of the lens by 0.75 D even if the lens is unchanged. This leads to a loss of 0.5 D loss of effectivity because the principal plane of the lens is further displaced back into the eye.

### **Postoperative change in corneal curvature**

Suturing of a cataract incision tends to steepen the vertical meridian and affects the post operative refraction of the patient.

### **Density of the cataract**

In a dense cataract the ultrasonic waves travel faster whereas in an early cataract the ultrasonic waves travel slower.

### **IOL tilt and decentration**

When a lens is tilted, its effective power increases and plus cylinder astigmatism is induced about the of the lens tilt. The tilting of the lens occurs if one loop is in the capsular bag and the other is in the sulcus. Alternatively, residual cortex can cause an inflammatory response which causes contraction and pulling unequally on parts of the loops and the optic.

### **A-scan biometry**

A-scan ultrasound probes use a frequency of approximately 10 million Hz. In A-scan biometry, the sound travels through the solid cornea, the liquid aqueous, the solid lens, the liquid vitreous, the solid retina, choroid, sclera, and then orbital tissue; therefore, it continually changes velocity. The known sound velocity through the cornea and the lens (average lens velocity for the cataract age group ie, approximately 50-65 y) is 1641 meters/second (m/s), and the velocity through the aqueous and vitreous is 1532 m/s. The average sound velocity through the phakic eye is 1550 m/s<sup>39</sup>. The sound velocity through the aphakic eye is 1532 m/s, and the velocity through the

pseudophakic eye is 1532 m/s plus the correction factor for the intraocular lens (IOL) material.<sup>40-44</sup>

In A-scan biometry, one thin, parallel sound beam is emitted from the probe tip at its given frequency of approximately 10 MHz, with an echo bouncing back into the probe tip as the sound beam strikes each interface the contact (or applanation method) of biometry was accomplished by gently placing the probe on the corneal vertex and directing the sound beam through the visual axis. This handheld method was most easily and accurately performed with the patient in a reclined position with the patient's head placed in front of the display screen of the biometer. The patient was instructed to look at a target affixed to the ceiling. Using a gentle on-and-off technique allowed for less corneal compression since the examiner's hand was braced more firmly.

When the sound beam incidence is perpendicular to the visual axis (upper image), most returning echoes are received back into the probe tip to be interpreted on the display as high-amplitude spikes. When the sound beam incidence is non perpendicular to the visual axis (lower image), part of the returning echo is reflected away from the probe tip, with only a portion received by the probe. As a result, the spikes will be compromised.

The echoes received back into the probe from each of these interfaces are converted by the biometer to spikes arising from baseline. In the case of a cataractous lens, multiple spikes occur within the central lens area as the sound beam strikes the

differing densities within the lens nucleus. This spike height, or amplitude, is therefore what gives the information on which to base the quality of the measurements.

### **Zeiss IOLMaster**

The Zeiss IOLMaster was approved by the United States Food and Drug Administration in March of 2000. A non-contact optical device that measures the distance from the corneal vertex to the retinal pigment epithelium by partial coherence interferometry, the IOL Master is consistently accurate to within  $\pm 0.02$  mm or better.<sup>45</sup> The IOL Master is the first such device to be widely used in clinical ophthalmology. Calibrated against the ultra-high resolution 40-MHz Grieshaber Biometric System, an internal algorithm approximates the distance to the vitreoretinal interface, for the equivalent of an immersion A-scan ultrasonic axial length.<sup>45</sup>

The IOLMaster is based on the principle of dual beam PCI and uses incident light of 780 nm wavelength emitted from a semiconductor diode laser in a Michelson interferometer set-up. This light is split by a beam splitting prism into two parallel beams of different optical paths and directed at the eye. The light is reflected by the optical surfaces of the eye and interference is produced if the optical path length of the two beams is equal. The interferometer mirror is moved longitudinally across the measuring range to locate constructive interference by a photo detector and therefore the position corresponding to the axial length.

Considering the fact that axial length measurements by A-scan ultrasonography (using a standard 10-MHz transducer) have a typical resolution of 0.10 mm to 0.12

mm, The IOLMaster uses infrared light source and has a fivefold increased accuracy in axial length measurements. The IOL Master allows fast, accurate measurements of eye length and surface curvature, necessary for cataract surgery. The IOL Master is more efficient because it allows measurements to be taken with complete confidence in the accuracy of the results. Also, because the IOL Master is non-contact (nothing touches the eye itself), there is no need for anesthesia and there is no potential for spread of contamination from the IOLMaster.<sup>45</sup>

Optical Biometry (PCI), Technology is based on laser interferometry with partial coherent light, often termed partial coherence interferometry (PCI). Resolution of axial length measurements is 0.01 mm. light of the IOL Master is reflected at the level of retinal pigment epithelium.<sup>45</sup>

## **TECHNIQUE**

Patient is seated on a chair with chin resting on the chin rest. The overview mode is used for course alignment. The patient looks at a small yellow fixation light. The patient then looks at the small red fixation light so that accurate axial length measurements are done. The examiner selects a best area and takes measurement of the axial length. An ideal axial length display is far more important than high signal noise ratio (SNR).

### **Ideal Axial Length Recording**

The characteristics are ;

1. SN ratio greater than 2.0.
2. Tall narrow primary maxima, with a thin well center termination and one set of secondary maxima.



3. At least 4 out of 20 measurements should be within 0.02mm of each other.

### **Pros/Cons of Optical Biometry**

#### **Pros**

- Non-contact → patient friendly, no risk of infection from patient to patient
- Speed of measurement (< 1 minute)
- Operator independent → high reproducibility of results.
- Machines (i.e. IOL Master) also calculate corneal curvature (K's), anterior chamber depth, and IOL power.

Non dependent on media (silicon filled eyes) and also useful in high myopes or hypermetropes. It is an examiner- independent tool providing reproducible and accurate values thereby decreasing deviation from the post operative target refraction. Can be performed easily in children.

#### **Cons**

IOLMaster being optical device, any media opacities in axial region will cause problem in measurement

- Poor signal reflected at the retina with:
- Dense cataracts –mature or dark brown/ black cataracts
- Epiretinal membranes
- Corneal scars or vitreous haemorrhage.
- Difficult to obtain measurements if patient is poor fixator.

IOLMaster measures the central power by Automated Keratometry. The instrument takes five Keratometry readings within 0.5 seconds and takes the average.

IOLMaster also measures anterior chamber depth using lateral slit illumination at approximately  $30^0$  to optical axis.

The various formulae put in IOLMaster are Holladay, SRK/T, Haigis, SRKII and Hoffer Q.

Thus with the introduction of IOLMaster, there is new era of high resolution lens power calculation which is highly accurate.

Points to be remembered while doing biometry are ;

IOLpower calculation should ideally be done for both the eyes though the operation is planned for one eye.

Measurement should be repeated if –

- Axial length is less than 22mm or more than 25mm.
- Difference between the 2 eyes is: mean corneal power more than 1D and axial length more than 0.3mm.

The study by **Bhatt et al (2008)** <sup>46</sup> **was done** to ascertain whether IOL Master or ultrasound biometry provides a more accurate prediction of refractive outcomes in cataract surgery. The mean (SD) of the difference between predicted refraction and final spherical equivalent was -0.43(0.84) diopters (D) for the IOLMaster and -0.60 (0.87)D for ultrasound biometry, indicating that, on average, the IOLMaster was a closer predictor than ultrasound biometry of the final spherical equivalent ( $p < .001$ ).

The IOLMaster had a 5% higher likelihood of predicting a spherical equivalent within 0.25 D than did ultrasound biometry ( $P=.06$ ), an 8% higher likelihood of predicting a spherical equivalent within 0.50 D ( $P<.001$ ), and an 8% higher likelihood of predicting a spherical equivalent within 1.00 D ( $P<.001$ ). These authors concluded that the IOL Master is a better predictor of postoperative refraction than ultrasound biometry, particularly within close ranges

**Rajan et al (2002)** <sup>47</sup> compared optical biometry based on the partial coherence laser interferometry principle to conventional ultrasound biometry in the accuracy of intraocular lens power calculations. The role of partial coherence laser interferometry in pseudophakic axial length measurement was analysed in the study. One hundred patients were included in this prospective randomised trial, of whom 50 patients underwent optical biometry by the partial coherence laser interferometry (PCLI) and 50 patients had biometry by applanation ultrasound. Eighty-seven percent of patients were within  $\pm 1$  D in the PCLI group as compared to 80% in the ultrasound group ( $P = 0.24$ ). The mean absolute error (MAE) of axial length difference with optical biometry was 0.13 mm  $\pm$  0.13 SD (range -0.42 to 0.78 mm) in the PCLI group and 0.19  $\pm$  0.13 mm in the ultrasound group. These authors concluded that non contact optical biometry using the PCLI principle improves the predictive value for postoperative refraction and is a reliable tool in the measurement of intraocular distances in pseudophakic eye

**Findl et al (2001)**<sup>48</sup> evaluated the feasibility of using a new optical biometry technique, namely, dual-beam partial coherence interferometry, to improve intraocular lens power prediction in cataract surgery. Preoperative axial length data obtained with PCI biometry and applanation ultrasound biometry in 77 eyes of 51 patients was applied to 4 commonly used IOL power formulas. The refractive outcome and the mean absolute error (MAE) were calculated for each formula using both biometry methods. Using PCI instead of ultrasound biometry significantly improved the refractive outcome with all 4 IOL power formulas. Partial coherence interferometry biometry applied to several widely used IOL power formulas yielded significantly better IOL power prediction and therefore refractive outcome in cataract surgery than ultrasound biometry.

**Kiss et al (2002)**<sup>49</sup> evaluated the refractive outcome of cataract patients 3 months postoperatively using optical biometry obtained with a prototype version (axial length measurement, ALM, Carl Zeiss Jena) of the commercial partial coherence interferometry instrument (IOLMaster). Forty five patients with age-related cataract in both eyes were scheduled for bilateral cataract surgery. Axial length was measured preoperatively with a prototype (ALM) of the commercial PCI instrument as well as with immersion ultrasound. Interestingly, refractive outcomes with the 2 techniques did not differ significantly ( $P = .28$ ).

**Eleftheriadis et al (2003)** <sup>50</sup> studied the refractive outcome of cataract surgery employing IOLMaster biometry data and compared it with that of applanation ultrasonography in a prospective study of 100 eyes that underwent phacoemulsification with intraocular lens implantation. The Holladay formula using IOLMaster data was employed for the prediction of implanted IOLs. One month after cataract surgery the refractive outcome was determined. Preoperative applanation ultrasonography data were used retrospectively to calculate the IOL prediction error. Then the two different biometry methods were compared. The optical axial length obtained by the IOLMaster was significantly longer ( $p < 0.001$ , Student's t test) than the axial length by applanation ultrasound, ((23.36 (SD 0.85) mm v 22.89 (0.83) mm)). The mean postoperative spherical equivalent was 0.00 (0.40) D and the mean prediction error -0.15 (0.38) D. This author concluded that IOLMaster optical biometry improves the refractive results of selected cataract surgery patients and is more accurate than applanation ultrasound biometry.

**Gokhan et al (2007)** <sup>51</sup> Compared the refractive outcomes of Optical Coherence Biometry and Applanation Ultrasound Biometry in 17 High-Myopic eyes with Posterior Pole Staphyloma. The optical coherence biometry provided more accurate IOL power calculations than did applanation ultrasound biometry in patients with high myopia and posterior pole staphyloma

**Rose et al (2003)** <sup>52</sup> conducted a study of comparison of axial length estimates using applanation A-scan ultrasound and the Zeiss IOL Master. The accuracy in predicting postoperative refraction determined by each method was also compared. On average the axial lengths measured by the IOL Master were longer by 0.15 mm compared to ultrasound biometry ( $P < 0.01$ ). Using the IOL Master over applanation ultrasound biometry significantly improved the postoperative refractive outcome from 0.65 D to 0.42 D ( $P = 0.011$ ). These authors concluded that IOL Master provides an accurate axial length measurement and results in accurate intraocular lens power calculation based on the SRK/T formula. Furthermore they feel that this is quick and easy to use and provides a non-contact technique with no risk of infection or corneal abrasion

**Vashist et al (2008)** <sup>53</sup> studied the prevalence of lens opacities in older people in 2 study centres in north and south India. Digital images of lens opacities were graded by type and severity using the lens opacity classification System III (LOCS). The prevalence of any cataract was 73.6% and similar in the two centres ( $p=0.2$ ). Type of cataract differed in prevalence between the centres; nuclear 60.0% in north India, 48.0% in south India; cortical 9.6% in north India and 12.8% in south India. Prevalence of any cataract rose with age and similar patterns with age and gender were observed for each type of cataract.

**Ueda et al (2010)** <sup>54</sup> evaluated the relationship between cataract density and the deviation from the predicted refraction. Axial length (AL) was measured in eyes mainly nuclear cataract using partial coherence interferometry (IOLMaster). The postoperative AL was measured in pseudophakic mode. The AL difference was calculated by subtracting the postoperative AL from the preoperative AL. Cataract density was measured with the pupil dilated using anterior segment Scheimpflug imaging. The predicted postoperative refraction was calculated using the SRK/T formula. The mean absolute prediction error (MAE) was calculated and correlated with cataract density ( $r=0.37$ ,  $P=.001$ ) and the AL difference ( $r=0.34$ ,  $P=.003$ ) but not with other parameters. The AL difference was correlated with cataract density ( $r=0.53$ ,  $P<.0001$ ). The postoperative refractive outcome was affected by cataract density.

# *Materials & Methods*



## MATERIALS AND METHODS

This study entitled “Comparison of refractive outcome between biometry with Applanation ultrasound and IOLMaster in eyes undergoing Phacoemulsification” was a prospective study on 100 eyes of 100 patients who attended Joseph Eye Hospital, Trichy, between January 2010 and April 2010. This study was approved by the Institutional Ethics Committee.

**Selection criteria** -Patients with age related cataracts with no other ocular pathology or history of ocular surgery were included in the study.

**Exclusion criteria**

- Age related macular degeneration
- Diabetic retinopathy
- Glaucoma
- Macular disorder
- corneal disorders
- Dense cataracts

Data collection and demographic details included; age, sex, pre-operative refractive error, type of cataract, type of IOL implantation, post operative visual acuity and post operative refractive value by the Autorefractometer at 6 weeks follow up visit.

- **Procedure** - The clinical history of each patient was first elicited for systemic illnesses such as Diabetes mellitus and Hypertension. Visual acuity was checked for the patients at 6 metres distance with Snellen's chart. A detailed slit lamp examination of the anterior segment was done and the type of cataract was recorded. Fundus examination was done in detail with +90D lens on all the patients. The refractive status of the patients was evaluated using an Autorefractometer (Topcon 8000B).
- The patients were randomised into 2 groups. Keratometry and A scan ultrasonography by Ocuscan was done in 50 patients and ocular biometry was done by IOL Master in 50 patients and the IOL power calculation was done based on SRK II formula.

A Scan ultrasound by Ocuscan- Procedure-The patient's cornea was anaesthetised by instilling 2% xylocaine eye drops and the probe was placed on the patients cornea. Probe is attached to a device that delivers adjustable sound waves. The measurements are displaced as spikes in the screen of an oscilloscope (visual monitor). The appearance of the spikes & the distance between them can be correlated to the structures within the eye & the distance between them.

Keratometry was done with the Automated keratometer where the central 3mm of the corneal curvature was measured.

Intraocular tension was recorded with the non contact tonometer (NCT). The type of IOL whether foldable or rigid IOL was selected according to the patients choice.

All the patients underwent uncomplicated Phacoemulsification surgery through a 3.2 mm superior temporal scleral incision with IOL implantation in the capsular bag by a single surgeon.

Post operatively all the patients were reviewed at 6 weeks, and Autorefractometry was done and the vision was recorded by Snellens chart. The residual astigmatism was calculated for all the cases by subtracting from the preoperative value.

The final spherical equivalent was evaluated and compared between the 2 groups. The results obtained are presented as mean (SD) values and measured range indicating minimums and maximums. For comparison of the means, paired students t test was used for statistical analysis.

- **SRK II FORMULA** - Was described by Donald Sanders, John Retzlaff and Kraff<sup>55-57</sup> in the mid 1980's. The formula attempted to predict the IOL power based on the axial length and the average central corneal power.
- $P = A - 2.5L - 0.9K$ .  
 $P$  = Lens implant power to produce emmetropia(D)

- $L$ =Axial length in millimeters.
- $K$ =average central corneal power in Diopters.
- $A$ =Specific constant for each lens type and/ or manufacturer

For each millimeter of change in axial length, a 2.5 D change in lens implant power occurs in opposite direction. The implant power for emmetropia decreases by 2.5 D for each millimeter increase in axial length, and vice versa.

For each diopters change in  $K$  reading, a 0.9 D change in lens implant power occurs in the opposite direction. The implant power for emmetropia decreases by 0.9 D for every diopters increase in  $K$  readings and vice versa. The  $A$  constant is greater, the closer the lens implant is to the retina the  $A$  constant for a given style of lens implant from the same manufacturer can be determined.

# *Results*

## RESULTS

In this prospective study performed at a tertiary eye care hospital in Tamilnadu from January 2010 to June 2010 (six months), 100 eyes of 100 patients, who were posted for phacoemulsification surgery, underwent preliminary testing of various parameters of refraction by conventional Ascan ultrasonography (50 eyes) or by the newer technique of partial coherence interferometry (PCI) using the IOLMaster<sup>TM</sup>.

### 1. AGE DISTRIBUTION

In the IOLMaster group five patients were 45-50 years of age, 18 patients were 56 to 60 years of age and 27 patients were 61 to 75 years of age. In the Ascan ultrasonography group, seven patients were in the age group 45-50 years, 14 patients in the age group 56 to 60 years and 29 patients in the age group 61 to 75 years (Table 1).

The mean age was  $60.82 \pm 10.5$  years in the IOLMaster group and  $60.64 \pm 11.2$  years in the Ascan ultrasonography group (Tables 2,3). This difference was not statistically significant [unpaired 't' test (degree of freedom (d. f.)=98) =0.0824; P(2-tailed)=0.9341].

### 2. GENDER DISTRIBUTION

There were 31 males (62%) and 19 females (38%) in the IOLMaster group, compared to 22 males (44%) and 28 females (56%) in the Ascan ultrasonography group (Table 4); this difference was not statistically significant (Pearson's chi-square (d.f=1) =3.25; P=0.07).

### **3. LATERALITY OF THE TEST EYE**

The right eye was the study eye in 31 patients and the left eye in 19 patients in the IOLMaster group, compared to 33 patients and 17 patients respectively in the Ascan ultrasonography group (Tables 2,3); this difference was not statistically significant [Pearson's chi-square (d.f=1)=0.492; P=0.48].

### **4. VISUAL ACUITY AT PRESENTATION**

The preoperative visual acuity of the test eyes in the IOL Master group was as follows; vision better than 6/24 in 22 (44%) eyes, vision between 6/36 and 6/60 in 13 (26%) eyes and vision worse than 6/60 in 15 (30%) eyes. In the Ascan ultrasonography group, vision less than 6/24 occurred in 19 (38%) eyes, between 6/36 and 6/60 in 13 (26%) eyes and vision worse than 6/60 in 18 (36%) patients.(Table 5) These differences were not statistically significant [Pearson's chi-square (d.f=2)=0.5; P>0.05]

### **5. INTRAOCULAR LENS (IOL) POWER**

A total of seven (14%) eyes had IOL power in the range of 16-18D in the IOLMaster group and four eyes (8%) in the Ascan ultrasonography group. In the 19-21D range, there were 31(62%) eyes in the IOLMaster group and 22 (44%) eyes in the Ascan ultrasonography group. In the 22-24D range there were 12 (24%) eyes in the IOLMaster group and 24 (48%) eyes in the Ascan ultrasonography group (Table 6). These differences were statistically significant [Pearson's chi square (d.f=2)=6.34; p<0.05].

## **6. AXIAL LENGTH**

The pre-operative mean axial length (AL) was  $23.27 \pm 0.98$  mm in the IOLMaster group and  $23.01 \pm 1.58$  mm in the Ascan ultrasonography group (Tables 2,3). This difference was not statistically significant [unpaired 't' test ( $d.f=98$ ) = 0.9888;  $P(2\text{-tailed}) = 0.3252$ ]

## **7. POSTOPERATIVE REFRACTION**

Six weeks following surgery, the mean spherical equivalent in the IOL Master group was  $0.5752 \pm 0.3450$  (Table 2), while the mean spherical equivalent in the Ascan ultrasonography group was  $0.6358 \pm 0.3918$  (Table 3); this difference was not statistically significant [unpaired 't' test ( $d.f=98$ ) = 0.9446;  $P(2\text{-tailed}) = 0.3472$ ].

In the IOLMaster group, nine (18%) of 50 eyes had a final refractive error of  $<0.25$  D and in the Ascan ultrasonography group, it was 12 (24%) of 50 eyes (Table 7); this difference was not statistically significant [Pearson's chi-square ( $d.f=1$ ) = 0.542;  $P(2\text{-tailed}) = 0.46$ ]

In the IOLMaster group, 23 (46%) of 50 eyes had a final refractive error of  $<0.5$  D and in the Ascan ultrasonography group it was 21 (42%) of 50 eyes; (Table 7); this difference was not statistically significant [Pearson's chi-square ( $d.f=1$ ) = 0.162;  $P(2\text{-tailed}) = 0.69$ ]



When comparing the number of eyes with a postoperative spherical equivalent  $\leq 1.0$  D, it was 44(88%) of 50 eyes in the IOLMaster group and 44(88%) of 50 eyes in the Ascan ultrasonography group (Table 7).

The number of eyes with  $>1.0$  D of postoperative refractive error was six (12%) of 50 eyes in the IOLMaster group and also six eyes (12%) in the Ascan ultrasonography group (Table 7)

## **8. POSTOPERATIVE VISUAL ACUITY**

The number of eyes with uncorrected visual acuity of 6/9 or better in the IOLMaster group was 37(74%) whereas in the Ascan ultrasonography group it was 39 (78%) (Table 8); this difference was not statistically significant [Pearson's chi square (d.f=1)=0.219;P(2- tailed) =0.639575]

The number of eyes with uncorrected visual acuity of 6/12 or better in the IOLMaster group was 46 eyes(92%) whereas the number of eyes with uncorrected visual acuity of 6/12 or better in the Ascan group was 47 eyes (94%) (Table 8); this difference was not statistically significant [Pearson's chi-square (d.f=1)] =0.154; P(2-tailed=0.69109).

## **9. TYPES OF CATARACT**

In the IOLMaster group, there were 36 (72%) eyes with nuclear cataract and 14 eyes (28%) with both nuclear and posterior subcapsular cataract, whereas in the Ascan group there were 35 (70%) eyes with nuclear cataract and 15(30%) eyes with both

nuclear and posterior subcapsular cataract(Table 9); and this difference was not statistically significant [Pearson's chi-square (d.f. =1)=0.049; P(2-tailed=0.825575]

#### **10. MISCELLANEOUS FACTORS POSSIBLY INFLUENCING OUTCOME**

Factors reported to influence the accuracy of pre-operative biometric measurements in relation to postoperative refractive outcomes include patient age and gender and pre-operative measurements of axial length and visual acuity. Hence these factors were evaluated by categorising patients according to the postoperative spherical equivalent (SE) into three groups; $\leq 0.5D$ ,  $>0.5$  to  $1.0D$  and  $>1.0D$ . In the IOLMaster group, 23 patients had post-operative spherical equivalent of  $\leq 0.5D$ , 21 had an SE of  $>0.5$  to  $1.0 D$ , and six had an SE  $>1.0D$  (Table 2);corresponding figures in the Ascan ultrasonography group were 22,22 and six (Table 3).

With reference to age, in the IOLMaster group,the mean age(in years) in the three categories ( $SE \leq 0.5D$ ,  $>0.5D$  to  $1.0D$ ,  $>1.0D$ ) was  $60.22 \pm 9.73$ ,  $60.62 \pm 10.7$  and  $63.83 \pm 13.8$ ,respectively;the differences were not statistically significant [one –way ANOVA,(d.f.=23)Fisher F-value=0.28,  $P=0.757$ ] (Table 2).

In the Ascan ultrasonography group, the mean age (in years) in the three categories of SE was  $60.77 \pm 9.58$ ,  $60.32 \pm 11.65$  and  $61.33 \pm 16.49$ , respectively, these differences were not statistically significant (one –way ANOVA [d.f.=2] Fisher F-value= 0.021;  $P=0.979$ ) (Table 3).

With reference to gender, in the IOLMaster group,there were 15 males and 8 females in the  $SE \leq 0.5D$  category, 13 males and 8 females in the  $SE >0.5 D$  to  $1.0 D$

category, and three males and three females in the  $SE > 1.0D$  category; these differences were not statistically significant (Pearson's chi-square [d.f.=13]=0.417;  $P=0.51$ ) (Table 2). In the Ascan ultrasonography group, there were 11 males and 11 females in the  $SE \leq 0.5D$  category, seven males and 15 females in the  $SE > 0.5$  to  $1.0D$  category, and four males and two females in the  $SE > 0.1 D$  category ; these differences were not statistically significant (Pearson's chi-square test [d.f.=1]=1.422,  $P=0.233$ ) (Table 3).

Another factor considered was the pre-operative axial length (AL). In the IOLMaster group, the mean AL(mm) was  $23.24 \pm 1.0$ ,  $23.21 \pm 1.06$  and  $23.19 \pm 0.67$  in the  $SE \leq 0.5D$ ,  $SE > 0.5$  to  $1.0 D$  and  $SE > 1.0 D$  categories, respectively (Table 2) ;these differences were not statistically significant (one way ANOVA [d.f.=2] Fisher F value=0.114;  $P=0.893$ ). Corresponding values in the Ascan ultrasonography group were  $23.23 \pm 2.13$ ,  $22.93 \pm 0.95$  and  $22.37 \pm 0.72$ mm respectively (Table 3); these differences were not statistically significant [one way ANOVA(d.f.=2)Fisher F value =0.735;  $P=0.485$ ].

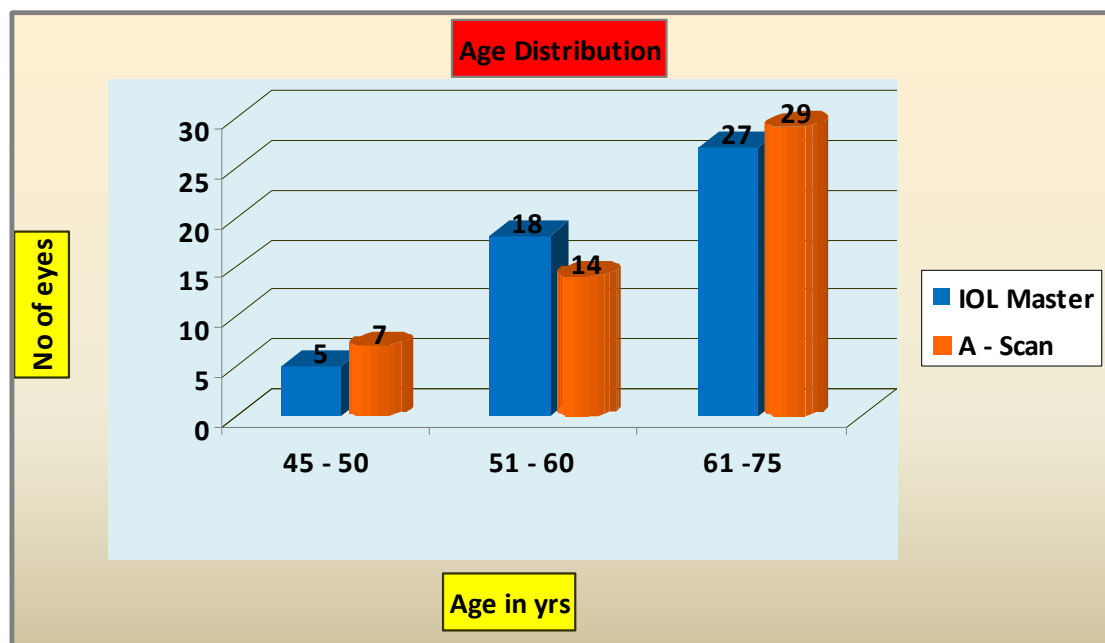
The pre-operative visual acuity was also considered as a possible influencing factor (Table 10). In the IOLMaster group, four (17%) of 23 patients in  $SE \leq 0.5 D$  category, four (19%) of 21 patients in the  $SE > 0.5$  to  $1.0D$  category and one(17%) of six patients in the  $SE > 1.0 D$  category had pre-operative visual acuity of 6/12 or better ;these differences were not statistically significant (chi-square [d.f.=1]=0.004;  $P=0.9465$ ). In the Ascan ultrasonography group, corresponding figures were four (18%) of 22, five (23%) of 22 and one(17%) of six; these differences were not statistically significant (chi-square [d.f.=1]=0.047;  $P=0.8277$ ).

**Table – 1**  
**Age distribution of patients in the study groups**

Age( in yrs)	Study groups	
	IOL Master*	A – Scan**
45 to 50	5	7
51 to 60	18	14
61 to 75	27	29

\*Patients underwent pre-operative biometry with IOLMaster .

\*\* Patients underwent pre-operative biometry with Ascan ultrasonography.



**Table - 2****Salient characteristics of Patients / Eyes in the IOLMaster group**

(underwent pre-operative biometry with IOLMaster)

Parameter	Overall	Categories based on Spherical Equivalent (SE)		
		$\leq 0.5D$	$>0.5$ TO $1.0D$	$>1.0D$
<b>Mean Age(yrs)</b>	$60.82 \pm 10.5$	$60.22 \pm 9.73$	$60.62 \pm 10.7$	<b><math>63.83 \pm 13.8</math></b>
<b>Gender</b>	M=31 F=19	M=15 F=8	M=13 F=8	<b>M=3 F=3</b>
<b>Affected eye</b>	R=31 L=19	R=15 L=8	R=11 L=10	<b>R=5 L=1</b>
<b>Mean axial length (AL) (mm)</b>	$23.27 \pm 0.98$	$23.34 \pm 1.0$	$23.21 \pm 1.06$	<b><math>23.19 \pm 0.67</math></b>
<b>Mean spherical equivalent (SE)</b>	<b><math>0.57 \pm 0.35 D</math></b>	-----	-----	-----

Abbreviations: M=males; F=females; R=right eye; L = left eye d.f. = degrees of freedom

**Statistical Analysis**

- Age: IOL Master vs. AScan Unpaired 't' test (d.f.=98)=0.0824; P(2-tailed)=0.9341
- Gender IOL Master vs. AScan Pearson's chi-square (d.f.=1) = 3.25; P(2-tailed)=0.07
- Pre-operative Axial Length: IOL Master vs AScan  
Unpaired 't' test (df.=98) = 0.9888; P (2-tailed)=0.3252
- Post-operative Spherical Equivalent(SE) : IOL Master vs. AScan  
Unpaired 't' test (d.f.=98)=0.9446;P(2-tailed)=0.3472
- IOL Master group: Age vs. SE category:  
One-Way Analysis of Variance (ANOVA) (d.f.=2) Fisher F value=0.28;  
P=0.757
- IOL Master group : Gender vs SE category: Pearson's chi-square (d.f.=1) = 0.417;P(2-tailed)=0.51
- IOL Master group: Axial Length vs SE category:  
One-Way Analysis of Variance (ANOVA) (d.f.=2) Fisher F value=-0.114;  
P=0.893

**Table - 3**  
**Salient Characteristics of Patients/Eyes in the A Scan**  
**Ultrasonography group**  
 (underwent Pre-operative Biometry with A Scan Ultrasonography)

Parameter	Overall	Categories based on Spherical Equivalent (S.E)		
		$\leq 0.5$ D	>0.5 to 1.0 D	> 1.0 D
<b>Men Age (Yrs.)</b>	60.64 $\pm$ 11.2	60.77 $\pm$ 9.58	60.32 $\pm$ 11.65	61.33 $\pm$ 16.49
<b>Gender</b>	M=22 F=28	M=11 F=11	M=7 F=15	M=4 F=2
<b>Affected eye</b>	R=33 L=17	R=15 L=7	R=15 L=7	R=3 L=3
<b>Mean axial length (AL) (mm.)</b>	23.01 $\pm$ 1.58	23.23 $\pm$ 2.13	22.93 $\pm$ 0.95	22.37 $\pm$ 0.72
<b>Mean spherical equivalent (SE)</b>	0.64 $\pm$ 0.39 D	-----	-----	-----

Abbreviations: M=males; F=females; R=right eye; L = left eye

#### Statistical Analysis

- a) Age.: AScan vs IOL Master Unpaired 't' test (d.f.=98)=0.0824; P(2-tailed)=0.9341
- b) Gender AScan vs IOL Master Pearson's chi-square (d.f.=1) = 3.25; P(2-tailed)=0.07
- c) Pre-operative Axial Length: AScan vs IOL Master  
Unpaired 't' test (d.f.=98) = 0.9888; P (2-tailed)=0.3252
- d) Post-operative Spherical Equivalent(SE) : AScan vs IOL Master  
Unpaired 't' test (d.f.=98)=0.9446;P(2-tailed)=0.3472
- e) A Scan Ultrasonography group: Age vs. SE category:  
One-Way Analysis of Variance (ANOVA) (d.f.=2) Fisher F value=0.021; P=0.979
- f) A Scan Ultrasonography group : Gender vs SE category: Pearson's chi-square (d.f.=1) = 1.422; P(2-tailed)=0.233
- g) A Scan Ultrasonography group: Axial Length vs SE category:  
One-Way Analysis of Variance (ANOVA) (d.f.=2) Fisher F value=-0.735; P=0.485

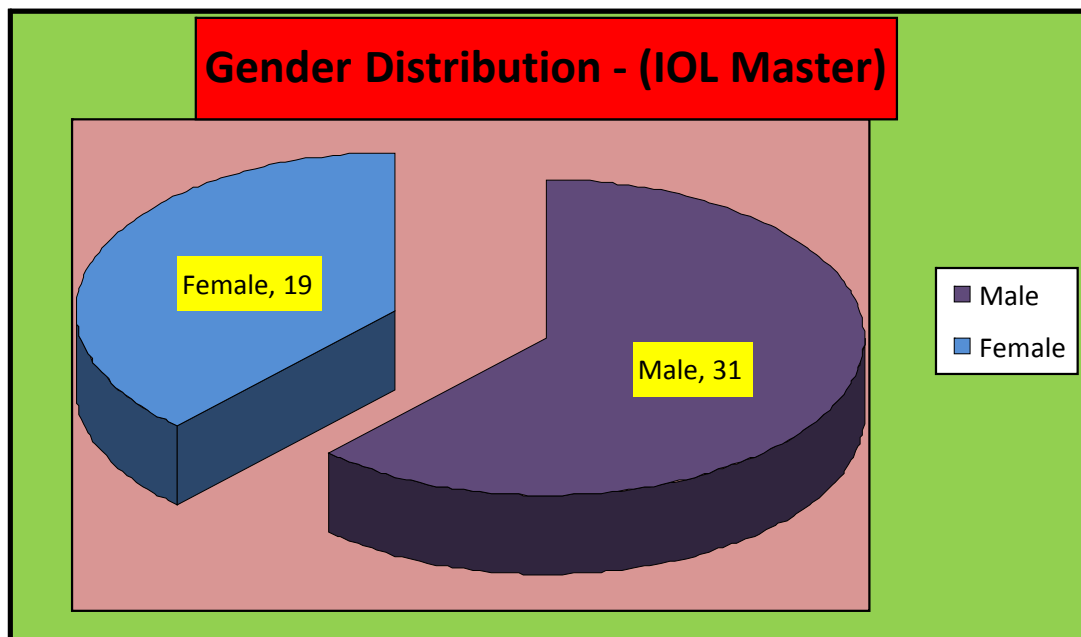
**Table – 4**

**Gender Distribution of Patients in the study groups**

Gender	Study Groups	
	IOL Master*	A – Scan**
Male	31	22
Female	19	28

\*Underwent Pre-operative Biometry with IOL Master

\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

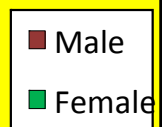
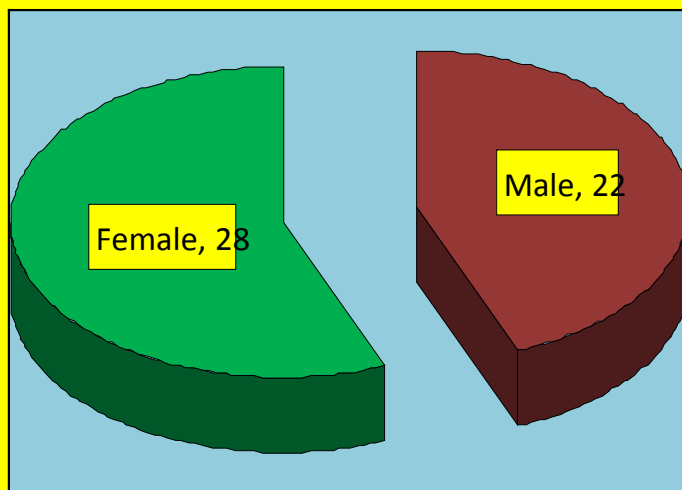


**Statistical Analysis ;**

Percentage of males in IOLMaster group vs percentage of males in Ascan group.

Pearson's chi-square (d.f.=1)=3.25; P=0.07

## Gender Distribution - (A - Scan)





**Table 5**

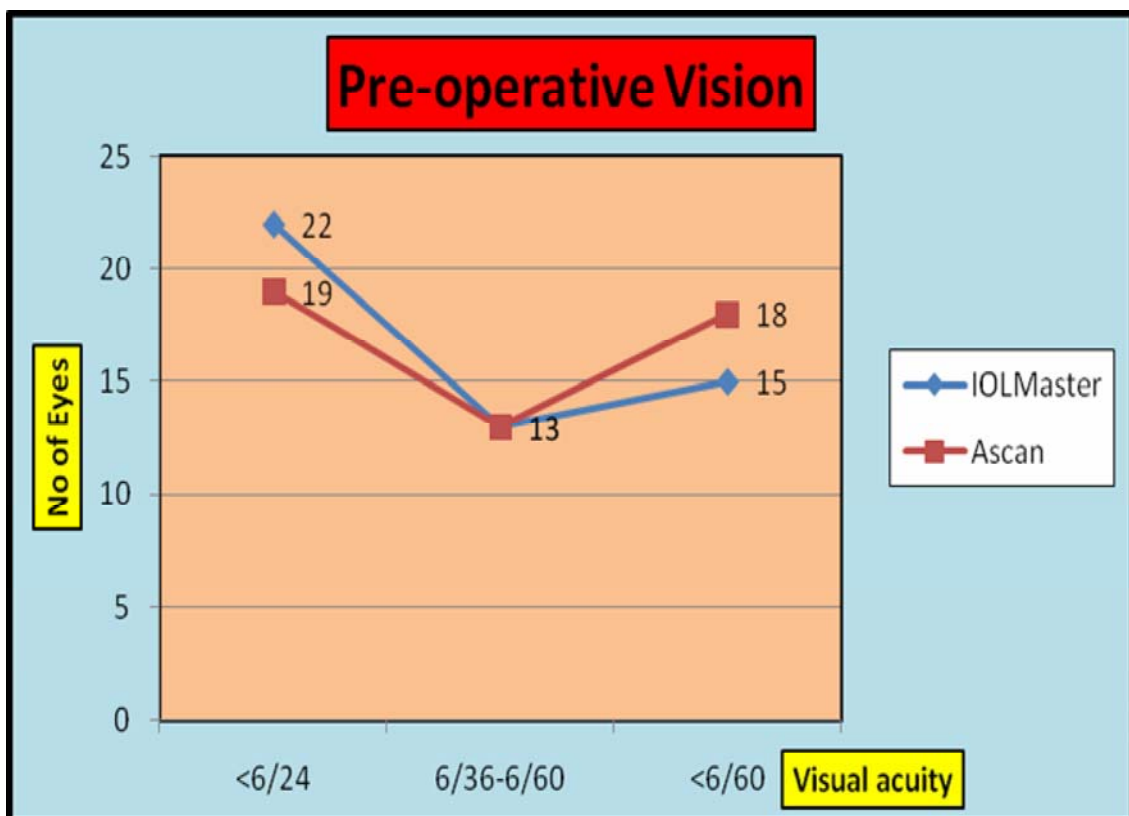
**Pre-operative Visual Acuity of Study Eyes**

<i>Pre operative vision</i>	<i>Study Eyes</i>	
Visual acuity	IOLMaster*	Ascan**
<6/24	22	19
6/36-6/60	13	13
>6/60	15	18

\*Underwent Pre-operative Biometry with IOL Master

\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

**Statistical Analysis** : IOL Master vs A Scan Groups; Pearson's chi square  
(d.f.2)=0.5;P(2 tailed)=>0.05



**Table – 6**

**Pre-operative Intraocular Lens Power calculation in the Study Eyes**

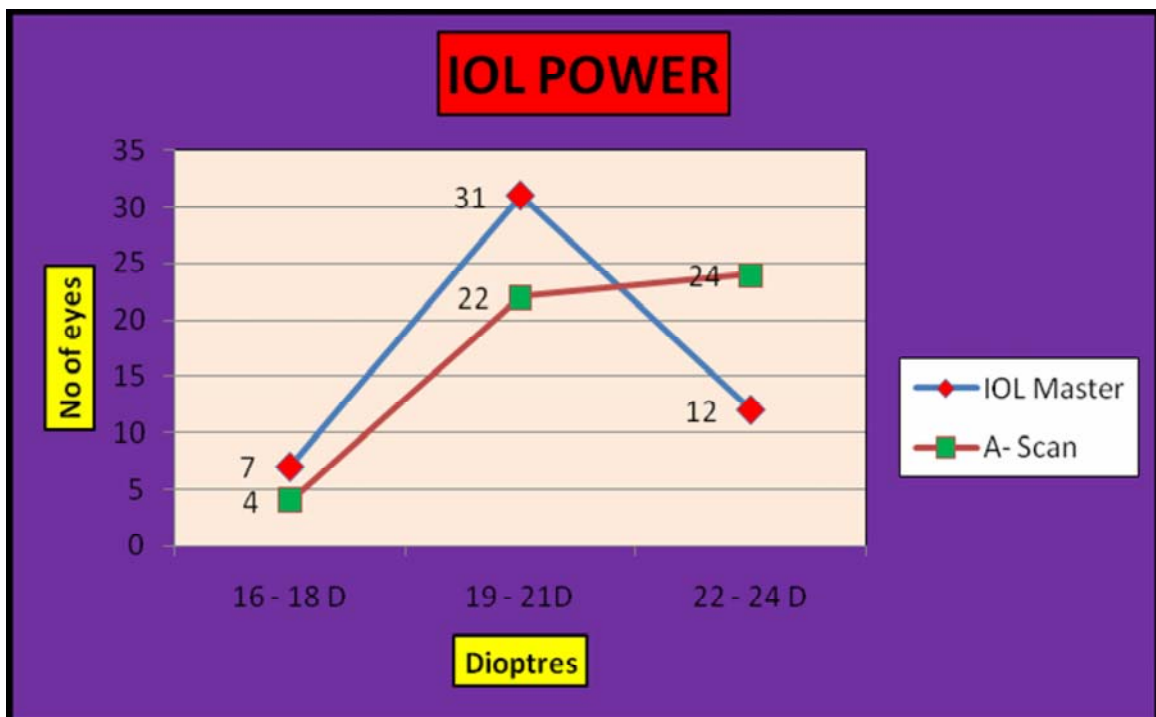
Pre-operative IOL Power Calculation	Study Eyes	
	IOL Master*	A- Scan**
16 - 18 D	7	4
19 - 21D	31	22
22 - 24 D	12	24

\*Underwent Pre-operative Biometry with IOL Master

\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

**Statistical Analysis :**

IOL Master vs A Scan Groups; Pearson's chi square (d.f.2)=6.34 ;P(2 tailed)=<0.05



**Table - 7**

**Post-Operative (Phacoemulsification) Refraction in the Study Eyes**

<b>Post-Operative Spherical Equivalent</b>	<b>IOL Master* (cumulative)</b>	<b>A scan** (cumulative)</b>
<b><math>\leq 0.25</math> D</b>	<b>9</b>	<b>12</b>
<b><math>\leq 0.5</math> D</b>	<b>23</b>	<b>21</b>
<b><math>\leq 1.0</math> D</b>	<b>44</b>	<b>44</b>
<b><math>&gt; 1.0</math> D</b>	<b>6</b>	<b>6</b>

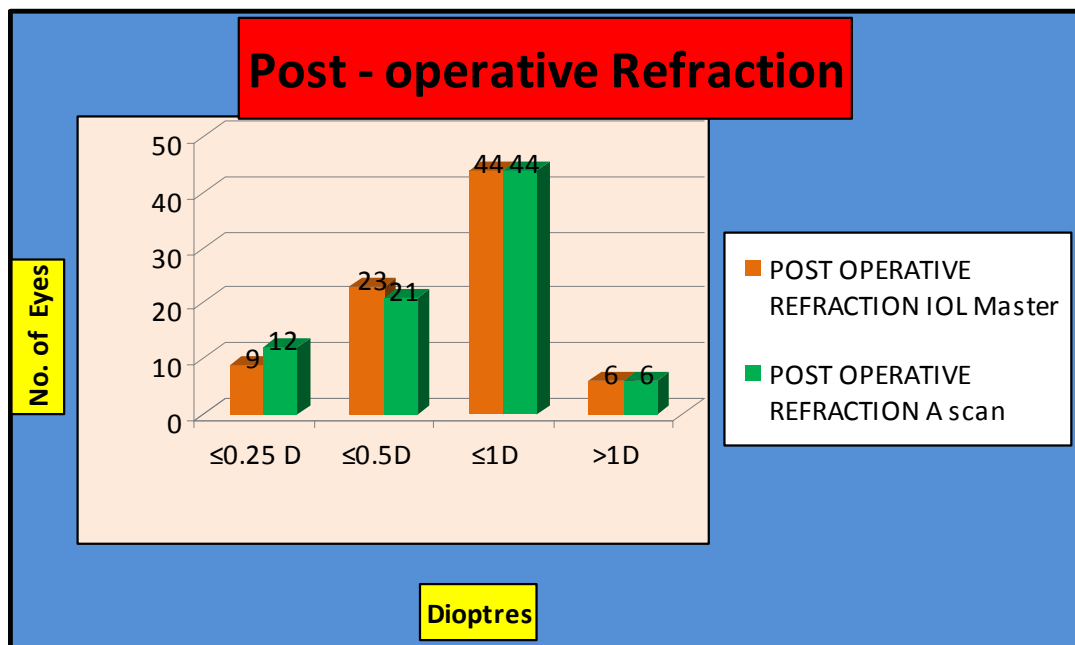
\*Underwent Pre-operative Biometry with IOL Master

\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

**Statistical Analysis :**

a)  $< 0.25$  D, IOL Master vs A Scan; chi-square=0.542;P=0.46

b)  $< 0.5$  D, IOLMaster VS Ascan;chi-square =0.162;P=0.69



**Table -8**  
**Post-Operative (Phacoemulsification) Visual Acuity in the Study Eyes**

Post – operative Visual Acuity	Study Eyes	
	IOL Master* (cumulative)	A – Scan** (cumulative)
6/6.	22	27
6/9.	37	39
6/12 .	46	47
6/18 .	50	50

\*Underwent Pre-operative Biometry with IOL Master

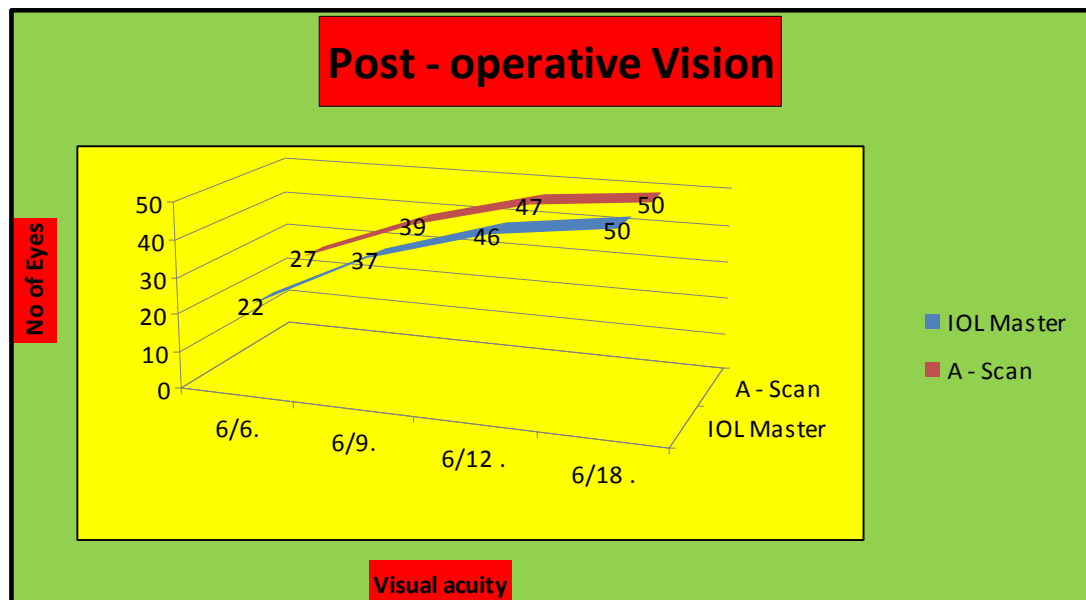
\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

**Statistical Analysis :**

a)V.A. of 6/9 or better, IOLMaster vs Ascan; Pearson's chi-square (d.f.=1)=0.219; P=0.64

b) V.A. of 6/12 or better, IOLMaster vs Ascan ; Pearson's chi-square

(d.f.=1)=0.154;P=0.69



**Table 9**  
**Types of Cataract in the Study Eyes**

Types of Cataract	Study Eyes	
	IOL Master*	A – scan**
Nuclear	36	35
Nuclear + Posterior subcapsular	14	15

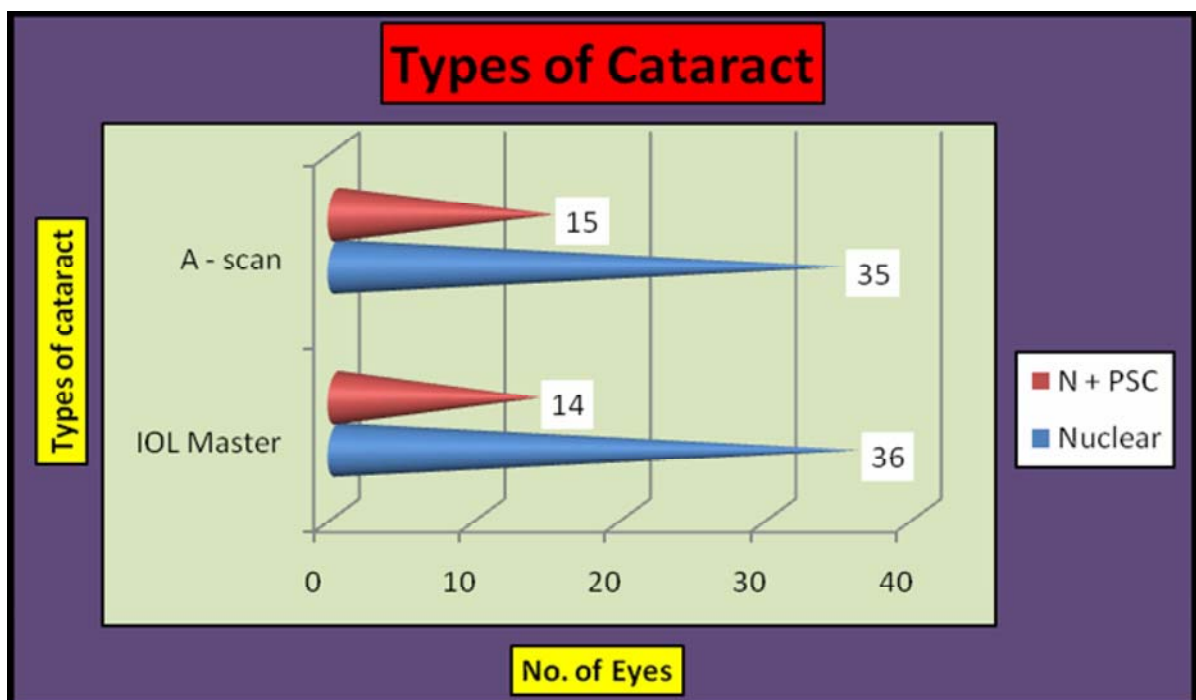
\*Underwent Pre-operative Biometry with IOL Master

\*\*Underwent Pre-operative Biometry with A Scan Ultrasonography

**Statistical Analysis :**

Nuclear cataract only, IOLMaster vs Ascan; Pearson's chi-square(d.f.=1) =0.049;

P=0.0825575].



**Table 10**

**Pre-operative Visual Acuity versus Post-operative Spherical Equivalent in Operated Eyes**

Pre-Operative visual acuity	SE (D) in IOL Master group			SE (D) In A Scan Ultrasonograph group		
	$\leq 0.5$	>0.5 to 1.0	> 1.0	$\leq 0.5$	>0.5 to 1.0	> 1.0
< 6/12	4	4	1	4	5	1
$\geq 6/18$	19	17	5	18	17	5
<b>Total</b>	<b>23</b>	<b>21</b>	<b>6</b>	<b>22</b>	<b>22</b>	<b>6</b>

Abbreviation : SE = Post –operative spherical equivalent

**Statistical Analysis**

a) IOL Master group : **Pre-operative visual acuity vs SE** category:

Pearson's chi-square (d.f=1) = 0.004; P(2-tailed) = 0.9465

b) A Scan ultrasonography group: **Pre-Operative visual acuity vs SE** category:

Pearson's chi-square (d.f.=1) = 0.047; P (2-tailed) = 0.8277



**PHOTO 2 – IOL MASTER**



**PHOTO 1 – AUTOKERATOMETER ( NIDEK )**





**PHOTO 3 – A- SCAN ( ALCON )**



**PHOTO 4 - TOPCON AUTO-REFRACTOMETER**

# *Discussion*

## DISCUSSION

Today, most patients expect to have excellent quality of vision after cataract surgery. To meet these expectations, there have been improvements in intraocular lens (IOL) calculation formulas (Narvaez et al., 2006)<sup>58</sup>, IOL design, and devices to measure axial length (Ueda et al. 2010)<sup>54</sup>.

In modern cataract surgery, the use of biometry allows surgeons to aim for a specific postoperative refraction (Kugelberg and Lundstrom 2008)<sup>59</sup>, which is usually between 0.0 diopter (D) and 0.5 D. With newer formulas, personalization of IOL constants and improvements in surgical technique, at least 90% of patients should have a spherical equivalent (SE) refraction within  $\pm 1.00$  D of the target refraction (Holladay et al., 1986; Olsen, 2007)<sup>60,61</sup>.

Recent publications on routine cataract surgery have reported that between 75% and 90% of surgeries result in a final refraction within  $\pm 1.00$  D of the target refraction (Lundstrom et al., 2001, 2002; Murphy et al., 2002; Daniel et al. 2003; Olsen, 2007)<sup>62-65</sup>.

However, in spite of all the advances made, measurement errors in keratometry, axial length and precision of the IOL power may occur, therein rendering it difficult to achieve an SE refraction within  $\pm 1.00$  D of the target refraction in routine cataract surgery, posing problems for patients (Kugelberg and Lundstrom, 2008)<sup>59</sup>.

Ultrasound was introduced in the 1970s for axial length biometry (Kraff et al. 1978) <sup>66</sup> and was considered for more than two decades to be the 'gold standard' for this indication. One reason why the ultrasonic biometry technique has been found so useful is possibly because it is able to penetrate a dense cataract (Weinstein and Baum, 1966) <sup>67</sup> However, with refinements in cataract surgery, many cataracts are being removed before dense opacity develops, and this has allowed optical biometry to emerge as a viable alternative to conventional A scan ultrasonography for preoperative biometry.

The infrared optical biometry system that is based on the principle of partial coherence interferometry (PCI) has found tangible expression in the form of the commercially-available PCI optical biometer, the IOLMaster<sup>TM</sup>. This instrument, the PCI optical biometer, performs biometry by a non-contact method, which does not require the use of topical anaesthesia, thus providing comfort to the patient and preventing corneal abrasions and the transmission of infections.

The device also offers the ease of obtaining keratometry values, anterior chamber depth and axial length measurements in a single sitting. These are significant advantages in comparison to conventional ultrasound biometry, which is time-consuming and which requires topical anaesthesia for corneal applanation.

Since its inception, the IOLMaster and its PCI prototypes have been extensively studied for IOL power calculation from axial length measurement (Drexler et al. 1998; Findl et al. 1998; Kiss et al. 2002) <sup>68-69</sup>, since axial length is the most influential parameter in calculation of the IOL power.

Furthermore, PCI optical biometry measures the ocular axial length in addition to the visual axis, as the patient fixates at the measurement beam, which ensures accurate measurement ; during ultrasound biometry, a misalignment between the measured axis and the visual axis may result in erroneously longer axial length measurements.

Employing optical biometry instead of ultrasound biometry has improved significantly the refractive results of cataract surgery. PCI optical biometry is reported to exhibit excellent intra- and interobserver reliability (Vogel et al. 2001<sup>70</sup>; Tehrani et al. 2003a)<sup>71</sup> and several authors (Drexler et al. 1998; Tehrani et al. 2003, among others) have reported that its performance is superior to applanation ultrasound biometry.

In the study by Bhatt et al<sup>46</sup>, the IOL Master was 0.17 D more accurate than ultrasound biometry in predicting the final spherical equivalent (a statistically significant result), and offered a slightly better prediction of the postoperative refraction than ultrasound biometry within the 0.25 D, 0.5 D and 1.00 D ranges.

Eleftheriadas<sup>50</sup> compared the refractive outcomes after cataract surgery between PCI optical biometry and ultrasound biometry, and found that the former gave better postoperative results. The precision of optical biometry in pseudophakic eyes is reported to be better by a factor of more than 20 than that achieved with ultrasound<sup>71</sup> (the disadvantages of using A-scan ultrasonography in pseudophakic eyes have been reported in earlier studies<sup>49</sup>).

Although the PCI optical biometer has simplified considerably the process of ocular biometry, and can yield rapid measurements with a precision 8 to 10 times that of ultrasound, doing so requires patience and cooperation on the part of both the patient and the technician operating the device. More importantly, pathological conditions, such as nystagmus, maculopathy and dense cataracts, may render the instrument useless.

Some studies have shown that 8-20% of patients cannot be measured with optical biometry due to poor fixation, dense cataract or corneal pathology<sup>72</sup>. Ueda et al.<sup>73</sup> reported that axial length measurements taken with the IOLMaster were slightly affected by the cataract density (although to a lesser extent than ultrasound biometry).

Freeman and Pesudovs<sup>74</sup> reported that posterior subcapsular cataracts with a Lens Opacities Classification System III score of greater than 3.5 and mature cataracts accounted for 16% of measurement failures with the IOLMaster<sup>75</sup>.

In India, there is a high prevalence rate of nuclear and posterior subcapsular cataracts, possibly due to excessive exposure to ultraviolet radiation, especially in the older rural population in which childhood and adult exposures to outdoor activities are high<sup>76-77</sup>; use of indoor biomass cooking fuels<sup>78-79</sup> and poor nutrition<sup>80-81</sup> may be other risk factors in this population.

In view of this important factor that potentially affects the results obtained with the PCI optical biometer, and because few such comparative studies have been done in

India, the present study was undertaken to compare the post-phacoemulsification refractive outcomes in eyes that had undergone preoperative conventional contact biometry (using A scan ultrasonography) and those that had undergone optical biometry (using PCI optical biometry[the IOLMaster]).

Patients with mature cataracts and dense nuclear cataracts were not included in the present study because in the PCI optical biometer (IOLMaster), light is strongly attenuated by opaque ocular media, making it more difficult to obtain reliable measurements.

In the present study, patients undergoing preoperative biometry were randomly assigned to undergo either A scan ultrasonography (50 eyes) or PCI optical biometry (50 eyes). There were no significant differences between these groups in the mean age( $60.82 \pm 10.5$  years in the IOL master group,  $60.64 \pm 11.2$  years in the A scan ultrasonography group), and also no significant differences in age distribution (Tables 1,2,3) and gender distribution (Tables 2,3,4); that is, the patients in the groups were age and gender (sex)- matched.

Similarly, the eyes in the groups were matched (no statistically significant differences) with respect to laterality (Tables 2,3), preoperative visual acuity (Table 5), preoperative axial length measurements (Tables 2,3) and types of cataract present (Table 9).



In the present study, the mean post-operative spherical equivalent was  $0.57 \pm 0.34$  D in the PCI optical biometer (IOLMaster) group and  $0.63 \pm 0.39$  D in the A scan ultrasonography group; this difference was not statistically significant (Tables 2,3). In a similar study done by Rajan et al.<sup>47</sup>, the post-operative mean absolute error (MAE) was  $0.6 \pm 0.4$  D in patients who underwent ultrasound biometry, which was not significantly different from the value obtained ( $0.52 \pm 0.35$  D) in the IOLMaster group.

In the present study, 88% of the patients in the PCI optical biometer (IOLMaster) group achieved postoperative refraction of  $\pm 1$  D as compared to 86% in the A scan ultrasonography group (Table 7). These results are similar to those obtained in an earlier study<sup>47</sup>, where 87 percent of the eyes in the IOLMaster group and 80 percent of the eyes in the ultrasound group achieved a postoperative refraction of  $\pm 1$  D spherical equivalent postoperatively. Interestingly, in the present study, preoperative IOL power calculations had yielded significant differences between the groups (Table 6); the significance of this observation is uncertain

In the present study, there were no significant differences between the groups in post-operative visual acuity (Table 8); 74% of eyes in the PCI optical biometer (IOLMaster group) and 78 % of eyes in the A scan ultrasonography group attained a visual acuity of 6/9 or better.

Thus, the results of the present study suggest that contact biometry (A scan ultrasonography) and optical biometry (using PCI optical biometer [IOLMaster]) are similar in their predictive capabilities.

In a postoperative study of 140 consecutive eyes undergoing cataract surgery, Kutschan and Wiegand<sup>82</sup> found that both contact ultrasound biometry and the IOLMaster were similar in their predictive capabilities, and concluded that the IOLMaster was easier to use. Similarly, Moieni et al<sup>83</sup>, who compared the refractive outcomes after phacoemulsification by ultrasound and optical biometry methods, found no significant difference between them.

In contrast, Rajan et al.<sup>47</sup> found that the use of optical biometry offered a better predictive value than the use of applanation axial biometry measurement. Interestingly, in a prospective study of 162 consecutive eyes undergoing cataract surgery, Gatenbein and Ruprecht<sup>84</sup> concluded that contact axial biometry offered a better prediction of final refraction than did IOLMaster, but that the IOLMaster was an easier and faster tool to use.

Verhulst<sup>85</sup> and Vrijghem and Skorkovska et al.<sup>86</sup> also found that in eyes with significant nuclear sclerotic cataract, axial biometry was still needed for accurate axial length measurement.

In the present study, it was found that a decrease in visual acuity decreased the probability of successful measurements with the PCI optical biometer (IOL Master). This observation is similar to that made by Mana Tehrani<sup>87</sup>, who correlated lenticular opacity and visual acuity with the probability of successful measurements, and found that 80% of eyes with an uncorrected visual acuity worse

than 20/200 and 65% with worse than 20/400, and 45% with worse than 20/800, could be measured.

Several factors, namely age and gender of the patient, and preoperative axial length and visual acuity of the eye involved, have been reported to influence the accuracy of pre-operative biometric measurements in relation to postoperative refractive outcomes (Kugelberg and Lundsrom, 2008). Hence, in the present study, an attempt was made to look at the possible influence of these variables.

One research group found older age to be a risk factor for deviation from emmetropia in pseudophakia (Nuzzi et al., 2001) <sup>88</sup>. In the study by Kugelberg and Lundstrom (2008), when preoperative visual acuity was excluded from the analysis, older age emerged as being associated with a larger post-operative refractive error. However, in the present study, age did not appear to influence the accuracy of post-operative refractive outcomes in either of the study groups (Tables 2,3).

Kugelberg and Lundstrom (2008), in their analysis, found that it was significantly more difficult to achieve the target refraction in female patients than in male patients; they found this to be surprising and hard to explain. Some studies have shown that women have a worse visual outcome than men after cataract surgery, but none of these studies analysed the refractive outcome (Murthy et al., 2001; Logan et al., 2005) <sup>89-90</sup>.

Although the findings reported by other workers are interesting, in the present study, gender (sex) did not appear to influence the accuracy of post-operative refractive outcomes in either of the study groups (Tables 2,3).

It has been reported that an axial length difference of 0.1 mm corresponds to a prediction error of 0.28 D (Olsen, 1992)<sup>37</sup>. Ueda et al (2010) recently observed that the mean absolute error (MAE) was significantly correlated with the axial length difference and cataract density; they also observed that the MAE based on postoperative axial length was smaller than that based on preoperative axial length, and the postoperative axial length was thus considered to be closer to the true axial length than the preoperative axial length (Ueda et al., 2010).

In the present study, only the preoperative axial length was measured. Although the findings reported by other workers are interesting, in the present study, preoperative axial length values did not appear to influence the accuracy of post-operative refractive outcomes in either of the study groups (Tables 2,3).

Kugelberg and Lundstrom (2008) reported that one important factor that affected the MAE was preoperative visual acuity; the lower preoperative visual acuity, the larger the mean absolute prediction error. They speculated that since a low preoperative vision is an indicator of dense cataract, it may hide posterior eye problems that could not be seen during the preoperative examination.

Biometry measurements are less reliable in eyes with a dense nuclear cataract (Eleftheriadis, 2003). In the present study, however, preoperative visual acuity readings did not appear to influence the accuracy of post-operative refractive outcomes in either of the study groups (Table 10).

The initial promising results obtained with the PCI optical biometer (IOLMaster) suggested its potential to supercede applanation ultrasound as the most utilized axial length measurement procedure. However, to supercede ultrasound, an alternative technique should be able to measure reliably across the same breadth of the clinical population. This is not the case with the PCI optical biometer (IOLMaster) as it exists now. The biggest problem is with the type of cataract that is being measured.

Cataracts, especially posterior subcapsular and mature cataracts, commonly cause acquisition failure of 20% when the PCI optical biometer (IOLMaster) is used. Since 100% of mature cataracts and posterior subcapsular cataracts with lens opacification classification (LOCS) III grade  $> 3.5$  cannot be measured, this provides a convenient clinical cut-off for the use of the IOLMaster<sup>66</sup>.

According to Chylack et al.<sup>91</sup>, measurement failure with IOLMaster may occur at even lower levels of posterior subcapsular cataract ( $3.5 > p2.5$ ), which may be related to the location of the cataracts. Measurement with the IOLMaster relies upon two rays of light; perhaps lower levels of posterior subcapsular cataracts might be located such that at least one of these rays is scattered, so that measurement acquisition is prevented.

In addition, it may not be possible to acquire measurements using the IOLMaster due to practical reasons, such as the inability to position the patient at the machine or due to tremor of the head, and also due to fixation problems, such as

macular degeneration or dense amblyopia (Connors et al. [2002] <sup>92</sup> and also Tehrani et al. <sup>93</sup>.

Two small recent case series have examined the effect of macular disease on the two techniques and suggested that the IOLMaster may be more accurate in these cases<sup>94-95</sup>. Schreker and Strobel and Haggis <sup>96</sup> concluded that eyes with normal cataracts and visual acuity worse than 20/200 without additional pathology were ideal candidates for preoperative biometry with the IOLMaster..

Similarly, in cases of moderate cataract without other pathology, in eyes filled with silicon oil, and in children, the IOLMaster provides accurate readings<sup>74</sup>. However, in cases of poor visual acuity, dense cataract and other pathology, creating poor clarity of media, A scan ultrasonography would probably be indicated<sup>73</sup>.

*Conclusion*

## CONCLUSION

Cataract extraction with the implantation of IOL is the most frequently performed ophthalmic surgical procedure. Accurate preoperative calculation of IOL power is necessary to attain the desired postoperative refraction; several factors (keratometry, anterior chamber depth, lens formulas) contribute to the calculation, but the preoperative axial length is the most critical variable of all.

Partial laser coherence interferometry (IOLMaster) has proven more accurate than ultrasound biometry in predicting the refractive outcome in patients in the west. However, most cataracts in Indian patients are dense nuclear and posterior subcapsular types, in which the IOL Master may fail to calculate the IOL power; in such instances, A scan ultrasonography may work better. The present study aimed to compare the outcomes of the two procedures in Indian patients.

The present study revealed that there was no significant difference between the two techniques in predicting post-operative refractive outcomes in this population of Indian patients undergoing phacoemulsification. There was also no significant difference in post-operative visual acuity between the two groups. Thus, although partial laser coherence interferometry (IOLMaster), being a non-contact procedure, offers the practicing ophthalmologist a slight advantage over ultrasound biometry because of increasing patient expectation and for precise post-operative refraction, A scan ultrasonography still holds the pride of place when dense nuclear, posterior subcapsular and mature cataracts are encountered.



*Summary*

## SUMMARY

Cataract extraction with the implantation of IOL is the most frequently performed ophthalmic surgical procedure. Accurate preoperative calculation of IOL power is necessary to attain the desired postoperative refraction; several factors (keratometry, anterior chamber depth, lens formulas) contribute to the calculation, but the preoperative axial length is the most critical variable of all.

Partial laser coherence interferometry (IOLMaster) has proven more accurate than ultrasound biometry in predicting the refractive outcome in patients in some studies.

However, most cataracts in Indian patients are dense nuclear and posterior subcapsular types, in which the IOL Master may fail to calculate the IOL power; in such instances, A scan ultrasonography may be the only option for IOL power calculation.

The present study aimed to compare the outcomes of the two procedures in Indian patients. One hundred eyes of 100 patients undergoing phacoemulsification were randomized to undergo biometry using the conventional Ascan (50 eyes) or by the newer technique of partial coherence interferometry (PCI) using the IOLMaster<sup>TM</sup> (50 eyes).

The mean age was  $60.82 \pm 10.5$  years in the IOLMaster group and  $60.64 \pm 11.2$  years in the Ascan ultrasonography group. This difference was not statistically significant.

There were 31 males (62%) and 19 females (38%) in the IOLMaster group, compared to 22 males (44%) and 28 females (56%) in the Ascan ultrasonography group; this difference was not statistically significant.

The preoperative visual acuity of the test eyes in the IOL Master group was as follows; vision better than 6/24 in 22 (44%) eyes, vision between 6/36 and 6/60 in 13 (26%) eyes and vision worse than 6/60 in 15 (30%) eyes.

In the Ascan ultrasonography group, vision less than 6/24 occurred in 19 (38%) eyes, between 6/36 and 6/60 in 13 (26%) eyes and vision worse than 6/60 in 18 (36%) patients. These differences were not statistically significant.

A total of seven (14%) eyes had IOL power in the range of 16-18D in the IOLMaster group and four eyes (8%) in the Ascan ultrasonography group. In the 19-21D range, there were 31(62%) eyes in the IOLMaster group and 22 (44%) eyes in the Ascan ultrasonography group. In the 22-24D range there were 12 (24%) eyes in the IOLMaster group and 24 (48%) eyes in the Ascan ultrasonography group. These differences were statistically significant.

The pre-operative mean axial length (AL) was  $23.27 \pm 0.98$  mm in the IOLMaster group and  $23.01 \pm 1.58$  mm in the Ascan ultrasonography group. This difference was not statistically significant.

Six weeks following surgery, the mean spherical equivalent in the IOL Master group was  $0.5752 \pm 0.3450$ , while the mean spherical equivalent in the Ascan ultrasonography group was  $0.6358 \pm 0.3918$ ; this difference was not statistically significant.

The number of eyes with uncorrected visual acuity of 6/9 or better in the IOLMaster group was 37(74%) whereas in the Ascan ultrasonography group it was 39(78%) ; this difference was not statistically significant.

In the IOLMaster group, there were 36 (72%) eyes with nuclear cataract and 14 eyes (28%) with both nuclear and posterior subcapsular cataract, whereas in the Ascan group there were 35 (70%) eyes with nuclear cataract and 15(30%) eyes with both nuclear and posterior subcapsular cataract; this difference was not statistically significant.

The present study revealed that there was no significant difference between the two techniques in predicting post-operative refractive outcomes in this population of Indian patients undergoing phacoemulsification. There was also no significant difference in post-operative visual acuity between the two groups.

Thus, although partial laser coherence interferometry (IOLMaster), being a non-contact procedure, offers the practicing ophthalmologist a slight advantage over ultrasound biometry because of increasing patient expectation and for precise post-operative refraction, A scan ultrasonography still holds a pride of place when dense nuclear, posterior subcapsular and mature cataracts are encountered.

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*Proforma*



## Proforma

NAME	-		
AGE	-		
SEX	-		
HOSPITAL NO	-		
ADDRESS	-		
VISUAL ACUITY	-	RE -	LE -
IOP	-	RE	LE -
ANTERIOR SEGMENT	-		
CATARACT TYPE	-		
FUNDUS	-		
PRE OP EVALUATION	-		
ULTRASOUND	-		IOL MASTER -
AXIAL LENGTH	-	K1	-
K1	-	K2	-
K2	-	AXIAL LENGTH	-
IOL POWER	-	IOLPOWER	-
TYPE OF SURGERY	-		
TYPE OF TUNNEL	-		
TYPE OF IOL	-		
IN THE BAG	-		SULCUS FIXATED -
POST OP REFRACTION	-	6 WEEKS -	AR -
POST OP VISION	-		

*Master Chart*

## IOL Master

SL NO	NAME	HOSP NO	AGE	SEX	VN OP EYE	OTHER EYE	K1	K2	AXL mm	IOL PO
1	NATARAJAN	654637	73	M	6/12.RE	6/12.	44.29D / 7.62mm@ 96	45.30 / 7.45mm@ 6	23.25mm	20
2	RAJESHWARI	763804	32	F	6/24LE	5/60.	43.83D/7.70mm@171	45.12D/7.48mm@81	23.64mm	19
3	BHANUMATHY	711181	60	F	6/24RE	6/24.	42.03D/8.03mm@74	42.78D/7.89mm@164	23.34mm	2
4	JAINAMBU	638551	70	F	6/36RE	6/36.	45.24D/7.46mm@97	46.36D/7.28mm@7	21.63mm	2
5	ELANKODI	763968	53	F	5/60RE	6/18.	45.36D/7.44mm@126	46.17D/7.31mm@36	22.24mm	21
6	P.PALANISAMY	765603	71	M	5/60RE	6/60.	43.10D/7.83mm@86	44.29D/7.62mm@176	23.44mm	20
7	BOOPATHY	765515	42	M	5/60LE	5/60.	46.36D/7.28mm@90	47.74D/7.07mm@0	22.25mm	20
8	A.RANJITHAM	762902	75	F	6/60LE	6/60.	45.18D/7.47mm@93	45.86D/7.36mm@3	22.48mm	2
9	R.RAJAMANI	766150	72	F	5/60LE	5/60.	46.62D/7.24mm@80	47.14D/7.16mm@170	21.22mm	2
10	R.INDRA	764531	75	F	6/18RE	6/36.	44.06D/7.66mm@84	44.58D/7.57mm@174	22.93mm	2
11	RAIDURAI	767938	50	M	6/60LE	5/60.	43.66D/7.73mm@37	44.29D/7.62mm@127	23.81mm	1
12	KAMALAM	767895	78	F	6/24RE	6/18.	45.12D/7.48mm@72	46.73D/7.30mm@162	22.66mm	20
13	SR.GONZAGAMARY	673420	70	F	6/24LE	6/36.	45.35D/7.44mm@68	45.73D/7.38mm@158	22.64mm	2
14	T.M.Md.BASHEER	763232	53	M	5/60LE	5/60.	41.77D/8.08mm@89	42.67D/7.91mm@179	25.39mm	16
15	PUSHPADOSS	766706	71	M	6/26LE	6/36.	48.42D/6.97mm@128	49.13D/6.87mm@38	21.18mm	22
16	N.CHINNAPILLAI	744396	65	M	6/60RE.	5/60.	44.41D/7.60mm@103	45.61D/7.40mm@13	23.03mm	20
17	SUBBULAXMI	778981	67	F	5/60RE.	6/9.	42.78D/7.89mm@87	43.49D/7.76mm@177	24.68mm	1
18	IRUDAYAMARY	763901	69	F	6/36RE	6/24.	43.72D/7.72mm@109	44.47D/7.59mm@19	22.62mm	2
19	G.SEKAR	693270	44	M	6/9RE	6/9.	43.66D/7.7mm@4	44.47D/7.59mm@94	23.46mm	2
20	JEGANATHAN	762376	59	M	6/6RE	6/9.	45.42D/7.43mm@158	46.17D/7.31mm@68	22.82mm	20
21	YESUDAS	764073	54	M	6/60RE.	6/9.	45.00D/7.55mm@69	45.49D/7.42mm@159	23.13mm	19
22	CHINNASAMI	745273	70	M	6/9LE	6/9.	44.41D/7.60mm@111	45.24D/7.46mm@21	23.40mm	19
23	SOOSAIRAJ.S	732245	68	M	5/60RE	5/60.	43.44D/7.77mm@95	44.00D/7.67mm@5	22.79mm	2
24	CHRISTABEL.N	763146	58	F	6/6LE	6/60.	42.56D/7.93mm@133	42.99D/7.85mm@43	23.91mm	2
25	REV.ASHOK KUMAR	713825	65	M	6/24RE	6/24.	43.38D/7.78mm@157	44.06D/7.66mm@67	24.59mm	1
26	LEELAVATHY	754049	64	F	6/12RE	6/18.	46.75D/7.22mm@99	47.34D/7.13mm@9	22.07mm	2
27	SIVALINGAM	761183	56	M	4/60LE	6/9.	44.88D/7.52mm@117	45.18D/7.47mm@27	23.66mm	19
28	V.SHANMUGAM	616264	56	M	6/12RE	6/9.	45.86D/7.36mm@163	46.81D/7.21mm@73	22.30mm	2
29	V.KARUPPAN	768356	55	M	6/36RE	6/12.	43.16D/7.80mm@98	44.12D/7.65mm@8	23.74mm	19
30	KARUPPAMMAL	768922	60	F	5/60LE	5/60.	45.30D/7.45mm@91	46.42D/7.27mm@1	21.89mm	2
31	ANNAPORANI	769904	58	F	4/60LE	6/60.	44.53D/7.58mm@71	44.76D/7.54mm@161	22.57mm	2
32	THIRUGNANASAMBA	745179	63	M	6/18RE	6/24.	42.24D/7.99mm@100	42.67D/7.91mm@12	24.39mm	1
33	HASSAN NAINAR	728366	65	M	6/60RE.	6/60.	46.17D/7.31mm@164	46.87D/7.20mm@74	24.79mm	1
34	PANEERSELVAN	756275	54	M	5/60LE	6/6.	42.61D/7.92mm@1	42.94D/7.86mm@91	23.38mm	21
35	A.J.SOLOMON	768683	53	M	6/60LE	5/60.	41.77D/8.08mm@78	42.61D/7.92mm@168	23.76mm	2
36	SHEIK DAWOOD	768343	50	M	5/60LE	5/60.	46.23D/7.30mm@165	46.55D/7.25mm@75	24.65mm	1
37	VARADHARAJAN	767848	78	M	6/36LE	6/60.	45.06D/7.49mm@86	45.92D/7.35mm@176	22.07mm	2
38	THIRIVENGADHAM	767658	65	M	6/12LE	6/9.	44.41D/7.60mm@83	45.42D/7.43mm@173	23.10mm	

## A Scan

1	VASANTHA.R.K	672656	61	F	6/9RE	6/12.	43.50D@153°	44.00@153	22.73mm	2
2	CHELLAMAL	764780	55	F	6/12RE	6/9.	43.00D	43.00D	22.60mm	2
3	SEETHAI CHANDRAKA	763609	59	F	1/60RE	5/60.	45.50D	46.25D@65	22.17mm	21
4	SEKAR .U	763463	51	M	6/12RE	6/12.	43.63D	43.63D	23.79mm	19
5	GOVINDARAJ	574115	68	M	6/12LE	6/24.	45.50D	45.50D	22.52mm	2
6	SR.ALOSIUS MARY	764534	73	F	5/60RE	6/60.	46.00D	46.00D	22.52mm	20
7	VASUKI	734487	46	F	3/60RE	3/60.	44.25D	44.50D@85	22.30mm	22
8	MOHAMED IBRAHIM	759445	62	M	6/36LE	6/36.	42.25D	43.75D	24.40mm	18
9	A.SIMON RAJ	750956	53	M	6/9RE	6/9.	42.25D	42.75D@160	23.18mm	2
10	JESSIE	7660665	63	F	5/60LE	5/60.	44.38D	44.38D	24.70mm	1
11	PUSHPAVALLI	761075	65	F	2/60RE	Nil	45.75D	47.00D@28	24.60mm	14
12	THAHIRABANU	761022	32	F	6/12RE	6/9.	44.50D	46.50@172	21.40mm	25
13	RENGARAJ	761547	67	M	HMRE	6/12.	45.50D	46.00@119	21.83mm	23
14	KULANDAIVELU	762190	71	M	5/60LE	6/12.	43.75D	44.25D	21.64mm	25
15	RANJITHAM	762902	75	F	6/60RE	6/60.	45.25D	45.25D	22.40mm	21
16	KALIFULLAH	713851	75	M	6/24LE	6/24.	43.50D	44.00D@105	22.9mm	21
17	AMSAVALLI	762537	50	F	6/18LE	6/18.	44.00D	44.50D@10	32.22mm	20
18	PREMA	730005	50	F	6/12RE	6/18.	44.12D	45.53D@99	22.12mm	2
19	P.VASANTHA	762907	52	F	6/60LE	6/18.	46.25D	46.25D	21.65mm	23
20	THIYAGARAJ	754652	56	M	6/60RE	6/60.	47.00D@90	47.25@90	21.58mm	2
21	PUSHPA SAMBADHAM	762533	67	F	1/60LE	6/60.	46.36D	46.55D	22.73mm	20
22	RAJAKUMARI	727383	57	F	6/24RE	6/12.	45.67D	46.17D	22.35mm	2
23	RAMAN .S	755535	62	M	6/24RE	6/36.	43.25D	44.00D@98	24.18mm	18
24	SUSHEELA	764222	60	F	5/60RE	6/9.	41.63D	41.63D	23.07mm	2
25	LOGISTHA NTHAN	766257	60	M	6/60LE	6/18.	40.38D	40.38D	24.35mm	2
26	VIJAYA	760976	55	F	6/9RE	6/12.	45.00D	45.50D@61	22.59mm	2
27	BASHA JAN	636335	62	M	6/18LE	6/18.	42.75D	42.75D	23.49mm	2
28	SELVARAJ	767604	45	M	6/60LE	6/36.	44.00D	44.75D@90	22.90mm	2
29	MUTHAIAN	764934	70	M	HMLE	6/12.	44.50D	45.23D@64	23.12mm	2
30	MUNIAMMAL DHARM	764634	47	F	2/60LE	6/36.	44.00D	44.75@43	22.71mm	21
31	AROCKIAMARY	710766	73	F	6/36RE	6/12.	44.13D	44.13D	22.20mm	2
32	J.S.MARY VAZ	767995	78	F	5/60LE	5/60.	43.75D	45.00@72	22.50mm	2
33	R.CHANDRSEKAR	772244	64	M	1/60RE	6/36.	44.0D	44.0D	23.24mm	20
34	F.VINCY	774612	65	F	6/36RE	6/60.	45.00D	45.50@52	23.39mm	1
35	R.ROSALIND	752585	68	F	6/18RE	6/18.	44.00D	44.25D	22.80mm	21
36	SR.LILY	746190	72	F	6/12E	6/24.	44.17D	44.17D	22.57mm	2
37	PERIYANAYAGAM	764789	62	M	6/36RE	6/36.	44.00D	44.75@40	24.11mm	1